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Polymer carriers for drug delivery in tissue engineering ☆

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Abstract

Growing demand for tissues and organs for transplantation and the inability to meet this need using by autogeneic (from the host) or allogeneic (from the same species) sources has led to the rapid development of tissue engineering as an alternative. Tissue engineering aims to replace or facilitate the regrowth of damaged or diseased tissue by applying a combination of biomaterials, cells and bioactive molecules. This review focuses on synthetic polymers that have been used for tissue growth scaffold fabrication and their applications in both cell and extracellular matrix support and controlling the release of cell growth and differentiation supporting drugs.

Keywords: Scaffold; Scaffold fabrication; Polyester; Collagen blends

Contents

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1. Introduction

Growing demand for tissues and organs for transplantation and the inability to fulfill this need using autogeneic (from the host) or allogeneic (from the same species) sources has led to the rapid development of tissue engineering as an alternative. Tissue engineering aims to replace or facilitate the regrowth of damaged or diseased tissue by applying the combination of biomaterials, cells and bioactive molecules [1].

Certain tissues in the body contain cells capable of initiating regeneration or repair after injury. Regeneration ability varies between different cell types and depends on the nature of the injury or insult. Tissues undergoing constant renewing (e.g. skin, bone marrow, intestinal mucosa) are capable of complete regrowth, however this ability depends on a variety of factors such as size and cause of injury, and age of individual. In comparison other tissue types such as heart muscle and nerves lack mechanisms of regeneration in adults. For these tissue types, stem cell biology offers the potential to grow tissue by following a developmental pathway.

Scaffolds are central components of many tissue engineering strategies because they provide an architectural context in which extracellular matrix, cell–cell and growth factor interactions combine to generate regenerative niches. There is a significant challenge in the design and manufacture of scaffolds that possess both a highly porous structure and the ability to control the release kinetics of growth factors over the period of tissue regeneration.

1.1. Material choices

Controlled drug delivery and its applications for tissue engineering for support and stimulation of tissue growth has attracted much attention over the last decade. The criteria for choosing materials to act as the foundation for a scaffold are challenging. The materials used must be safe, not cause excessive immune responses, possess acceptable biocompatibility, be non-toxic and erodable. On the other hand the materials must possess appropriate mechanical properties and be suitable for manufacturing techniques that generate high surface area porous structures.

The materials that combine such characteristics can be divided in two main categories: natural polymers including alginate, collagen, hyaluronan, chitosan and gelatin and synthetic polymers including polyesters, polyaminoamides, polyacrylates and their copolymers and blends.

1.2. The role of the scaffold

Scaffolds for tissue engineering should answer several demands:

1. Should have mechanical properties matching those of the tissue at the implantation site or mechanical properties that are sufficient to shield cells from damaging compressive or tensile forces without inhibiting appropriate biomechanical cues.
2. Possess acceptable biocompatibility and toxicity profiles.
3. Mimic the native extracellular matrix (ECM), an endogenous substance that surrounds cells, binds them into tissues and provide signals that aid cellular development and morphogenesis.
4. Interface adherence: defined as how cells or proteins attach on scaffold surface. The scaffold should support cell adhesion and proliferation, facilitating cell–cell contact and cell migration.
5. Degradation rate: biodegradable scaffolds should be bioadsorbed at pre determined time-period, and the space initially occupied by the scaffolds should be replaced by grown tissue.

Synthetic polymer scaffolds may be used to deliver proteins and growth factors with or without cells locally to enhance